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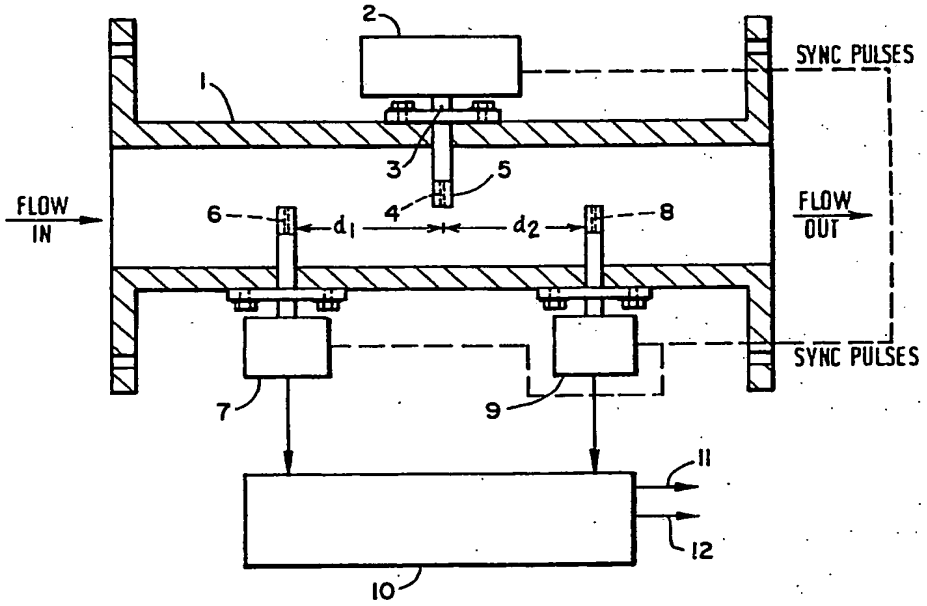

(57) Abstract

A device for measuring the concentration of two substances through the transmission of electromagnetic waves. The device utilizes at least one transmission element for transmitting a signal and at least two receiving elements for receiving a signal from the at least one transmission element and providing first and second output signals. The present invention also utilizes a receiving device for receiving the first and second output signals from the at least two receiving elements such that the difference or ratio of the two signals is utilized to determine the concentration.

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Description

Improvements to Oil/Water Measurement

Technical Field

The present invention relates to a device to measure content and velocity of aqueous and hydrocarbon mixtures in both oil-continuous and water-continuous phases.

Background Art

There are numerous devices on the market which utilize the change in the dielectric constant to determine the amount of water in oil. These devices operate only in the oil-continuous phase, i.e. as long as the mixture behaves like a dielectric. However, as soon as the mixture changes to water-continuous, it stops being an insulator (dielectric) and the instrument indicates 100% water.

Other techniques which utilize optical principles suffer from a lack of sensitivity at the oil-continuous phase and cannot cope with thick oil build-up without frequent cleaning. Changes in the salinity of the water also tend to affect the absolute measurement of such parameters, e.g. refractive index, conductivity, dielectric constant, etc. Nuclear absorption, while giving good results with binary mixtures, are overmasked by heavy

metallic contaminants, such as sulfur, vanadium, etc. Particle size in the water-continuous phase also plays an important part and affects the reading greatly.

Brief Description of the Drawings

A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

Figure 1 show the conduit and measuring system of the present invention;

Figure 2A shows another embodiment of the present invention using a "patch" type antenna;

Figure 2B show an end view of Figure 2A;

Figure 2C shows a similar arrangement to Figure 2B but having a rectangular cross-section;

Figure 3 shows another embodiment of the present invention; and

Figure 4 shows another embodiment of the present invention using an insertion type probe.

Best Mode for Carrying Out the Invention

Fig. 1 describes such system which carries the dual purpose of measuring the hydrocarbon/water ratio and fluid velocity.

Figure 1 shows a conduit (1) for the fluid flow. the conduit (1) may have a circular or rectangular cross-section. Transmitter (2) transmits a high frequency signal via a coaxial cable (3) or a wave guide, to an antenna (4), which can be any known antenna such as a "horn", "patch", "monopole" or "dipole" antenna, which is insulated from the fluid by means of an insulator (5). Receivers (7) and (9) are connected to similar antennae arrangements (6) and (8), which are spaced from the transmitting antenna (4) distance "d_1" and "d_2" where "d_2" is normally twice "d_1". A divider (10) divides the outputs of receivers (7) and (9) and supplies a linearized output of the ratio of P_1/P_2, wherein P_1 is the value of the signal received at (7) and P_2 is the value of the signal received at (9). Accordingly, either a vector ratio, a vector difference or the phase difference between the two receiving signals can be used to measure the concentration of the two substances to be measured.

This linearizer may take the form of the curve selector linearizer, as disclosed in U.S. Patent 4,774,680.

The "electrical loading" or impedance of fluid acting on antenna (4) will vary with the electrical characteristics of the fluid (this phenomena was utilized in U.S. Patent 4,503,383) and thus the amount of energy transmitted will be affected by the nature of the fluid. The major problem with devices that utilize such measuring techniques is that the fluid and the surface of insulator (5) predominates the effect, in particular when the fluid consists of two immicible fluids such as water with a few drops of oil in it. If this mixture is not homogeneous, or the droplets size and coated thickness vary, the loading will be greatly affected by it. U.S. Patent Application 07/311,610 is trying to overcome it by trying to predict this effect and prediction requires many tests to get the required parameters, and is only correct for a restricted range of products, temperature and velocity. Thus, if one can measure the bulk properties of this fluid, these problems are overcomed.

The present invention achieves these goals by measuring the ratio and/or the phase difference of the powers received by each receiver (7) and (9). As oil absorbs very little energy while water does, the amount of

power received in each antenna is a function of the water content and the distance from the transmitting antenna. By taking the ratio and/or the phase difference of these signals, output (12) becomes independent of surface coating, etc. as both antennae (6) and (8) are exposed to the same fluid in exactly the same way. By installing the antennae axially with the flow, and in such a way that one receiving antenna receives its signal with the direction of the flow, while the other, which is equally spaced, receives its signal against the direction of flow, the phase difference between these two received signals is directly proportional to the flow's velocity.

By transmitting at a frequency where the phase difference between the two signals due to the dielectric constant of water $E = E' - jE''$ is maximum (around 2.45 GHz) the effect of salinity is greatly reduced. Also by using two or more distinct frequencies, say 2.45 GHz and 15 GHz, one can obtain more inside information about the fluids' components. Higher frequencies such as infrared, visual light, ultraviolet, X-rays and gamma-rays are also applicable. Naturally, the "antennae" will be made to suit each wavelength.

Fig. 2A shows another embodiment of the invention, according to which the receiving "monopole" antennae are

replaced by two "patch" type (or similar) antennae.

All the other features such as the transmitter (2) and Phase Detector (10) of Fig. 1 are also common to Fig. 2A. The antennae arrangement in Fig. 2A is shown in 2 planes perpendicular to each other to demonstrate that two pairs of antennae can be used in any plane, not necessarily just opposite each other as shown in Fig. 1. Note that for clarity, only one pair is shown in Fig. 2A. The other pair is omitted for clarity sake. Also, only the "Patch" type is shown. Naturally, other types of known antennae configurations can be used, such as "horn", monopoles, dipoles, etc.

Fig. 2B shows an end view of Fig. 2A, where one monopole transmitter antenna (4) is used in the center and two receiving antennae (13) & (14). Fig. 2B shows a circular cross-section waveguide, while Fig. 2C shows a similar arrangement with a rectangular cross-section waveguide. Again, other types of conventional antennae can be used in this configuration such as two pairs of monopoles, "horn" type, etc. The transmitting antenna can be shared, or split into two separate ones. The advantage of two separate pairs is the elimination of cross-coupling between one receiving antenna and the other. The peripheral equipment surrounding the prime sensor is the

same as shown in Fig. 1.

Fig. 3 shows another possible way to achieve the same end, using one dipole transmitting antenna, and two dipole receiving antennae. The drawing shows such arrangement in a circular waveguide. Naturally, the more conventional rectangular waveguide can also be used. Fig. 3 shows how to achieve the required differential distances d_1 and d_2 in one specific way. The antennae can be located in one plane, or spaced axially, too. Spacing the antennae axially lowers their cross-coupling which improves the linearity of the measured signal. Again, instead of sharing one transmitter antenna, two independent pairs can be used to further reduce the cross-coupling. The peripheral equipment is the same as shown in Fig. 1.

Fig. 4 shows an insertion-type probe (16) inserted into a large conduit (17). Again, instead of the monopoles shown, dipoles and other type antennae can be used. Probe (16) is shown welded to pipe (17), but any other form of attachment can be used, e.g. the use of a seal-housing as described in U.S. Patent 4,503,383. Similar peripheral electronics as described in Fig. 1 can be used for signal conversion.

Claims

1. A device for measuring the concentration of two substances through the transmission of electromagnetic waves, said device comprising:

(a) at least one transmission element for transmitting a signal;

(b) at least two receiving elements for receiving the signal from said at least one transmission element and providing first and second output signals, said at least two receiving elements being spaced at two separate distances from said transmission element; and

(c) means for receiving the first and second output signals from said at least two receiving elements, wherein the difference in the first and second output signals is utilized to determine the concentration of the two substances.

2. The device according to Claim 1 wherein the difference in the first and second output signals is a phase difference between the first and second output signals.

3. The device according to Claim 2 wherein the phase difference between the first and second output signals is used to determine the velocity of the fluid passing said at least two receiving elements.

4. The device according to Claim 1 wherein the difference in the first and second output signals is an amplitude difference between the first and second output signals.

5. The device according to Claim 1 wherein said difference of the first and second output signals is a power difference between the first and second output signals.

6. The device according to Claim 1 wherein said at least two receiving elements are capable of being disposed in one or more planes.

7. The device according to Claim 1 wherein each of said at least two receiving elements and said at least one transmission element is selected from the group consisting of a patch antennae, horn antennae, monopole antennae, and dipole antennae.

8. The device according to Claim 1 wherein each of

said at least one transmission element and said at least two receiving elements is a probe means which can be inserted in the two substances.

9. The device according to Claim 7 wherein each of said probe means is capable of being disposed parallel to or perpendicular to the flow of the two substances.

10. The device according to Claim 1 wherein said at least one transmission element transmits a pulsed signal.

11. The device according to Claim 10 wherein the pulsed signal synchronizes the first and second output signals with the signal transmitted by said at least one transmission element.

12. A device for measuring the concentration of two substances through the transmission of electromagnetic waves, said device comprising:

(a) at least one transmission element for transmitting a signal;

(b) at least two receiving elements for receiving the signal from said at least one transmission element and providing first and second output signals, said at least

two receiving elements being spaced at two separate distances from said transmission element; and

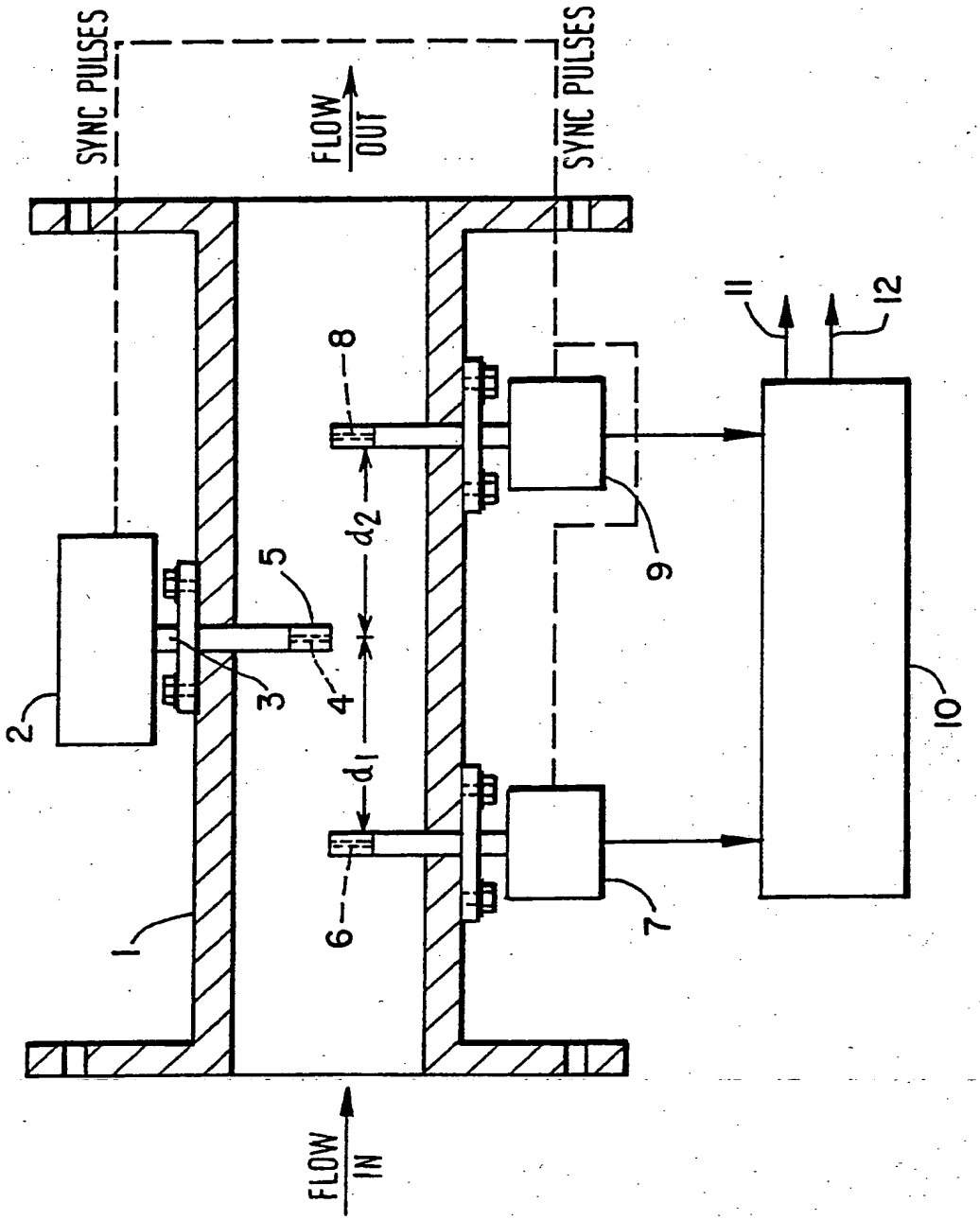
(c) means for receiving the first and second output signals from said at least two receiving elements, wherein a ratio of said first and second output signals is utilized to determine the concentration of the two substances.

13. The device according to Claim 12 wherein said ratio of the first and second output signals is an amplitude ratio of the first and second output signals.

14. The device according to Claim 12 wherein said ratio of the first and second output signals is a power ratio of the first and second output signals.

15. A method of assessing a characteristic of a multi-component fluid, which comprises comparing a characteristic of at least two electromagnetic signals that have taken different paths through the fluid.

FIG.1.


SYNC PULSES
FLOW OUT
SYNC PULSES
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12
8
d2
5
9
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3
4
10
d1
1
6
7
FLOW IN

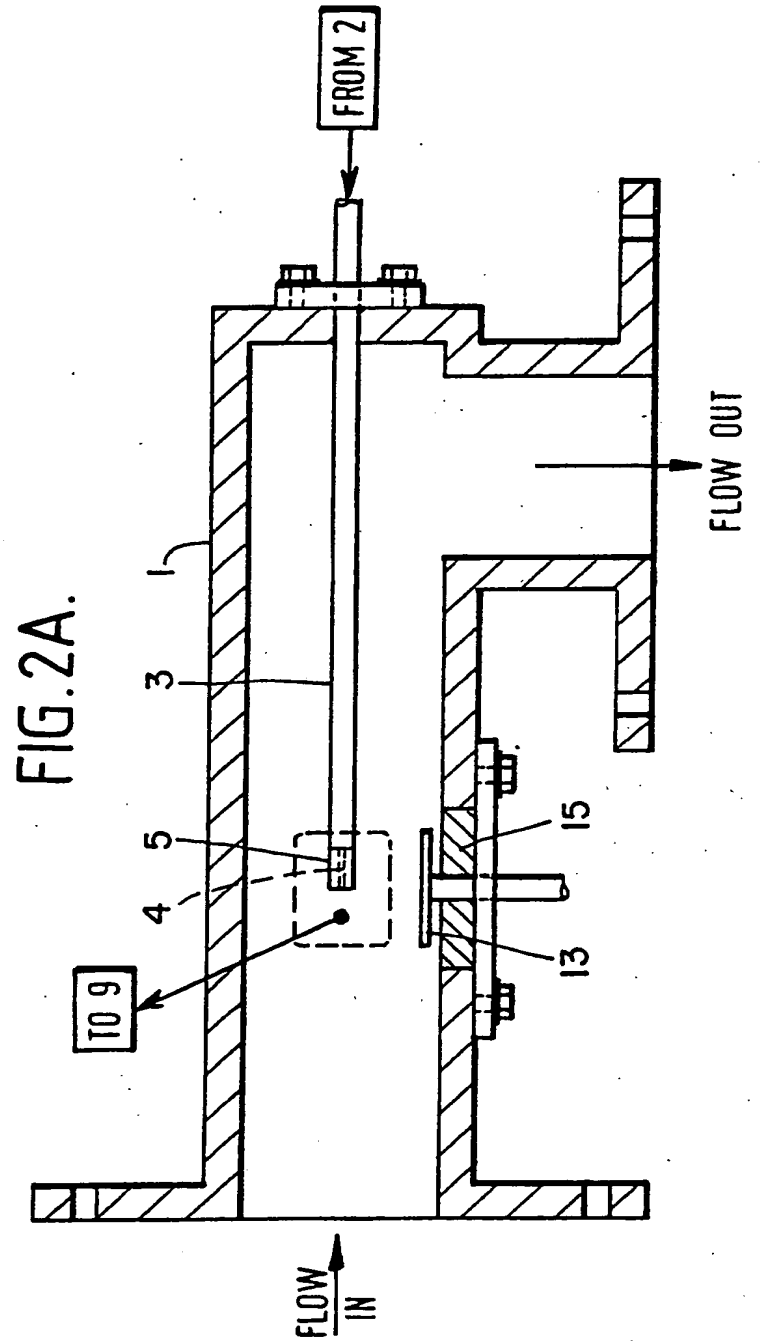


FIG.2A.

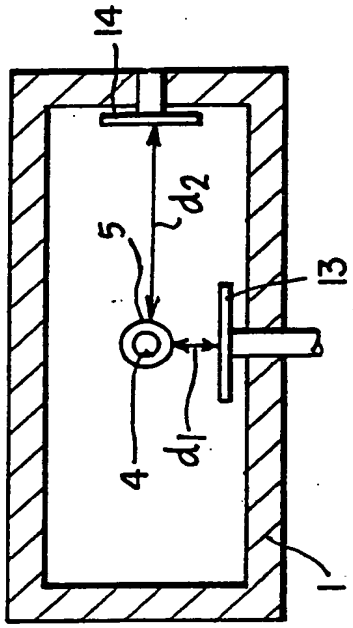


FIG.2C.

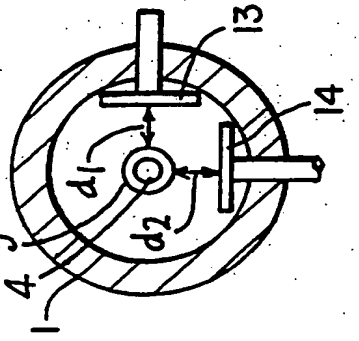


FIG.2B.

FIG.3.

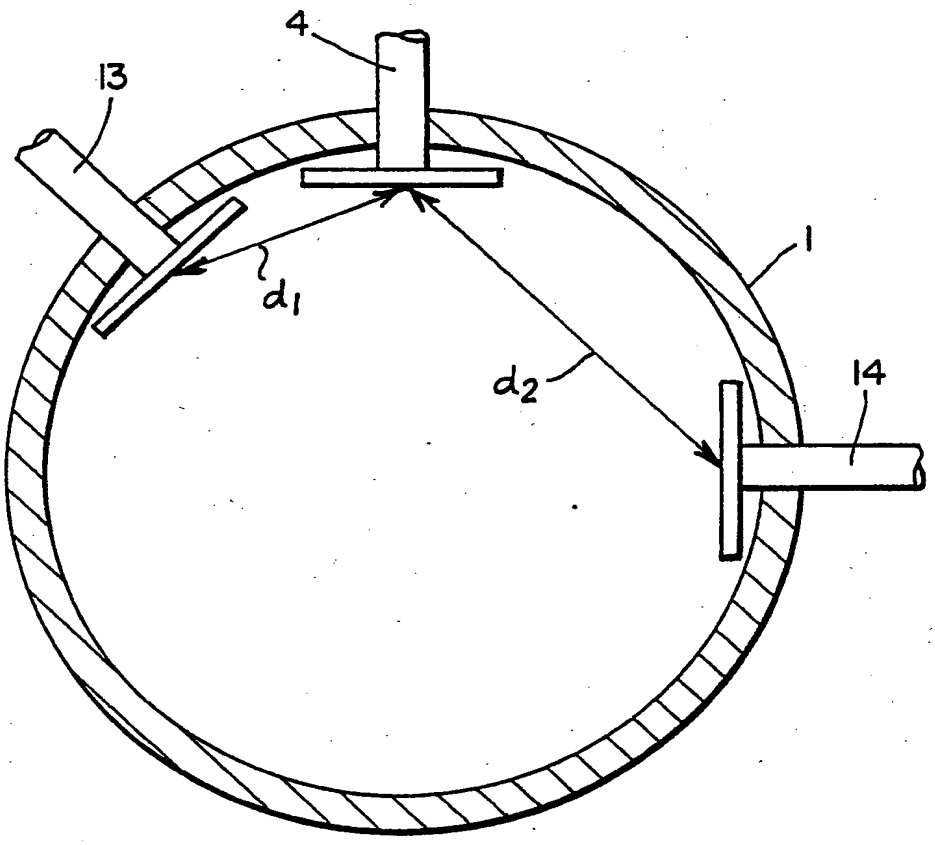
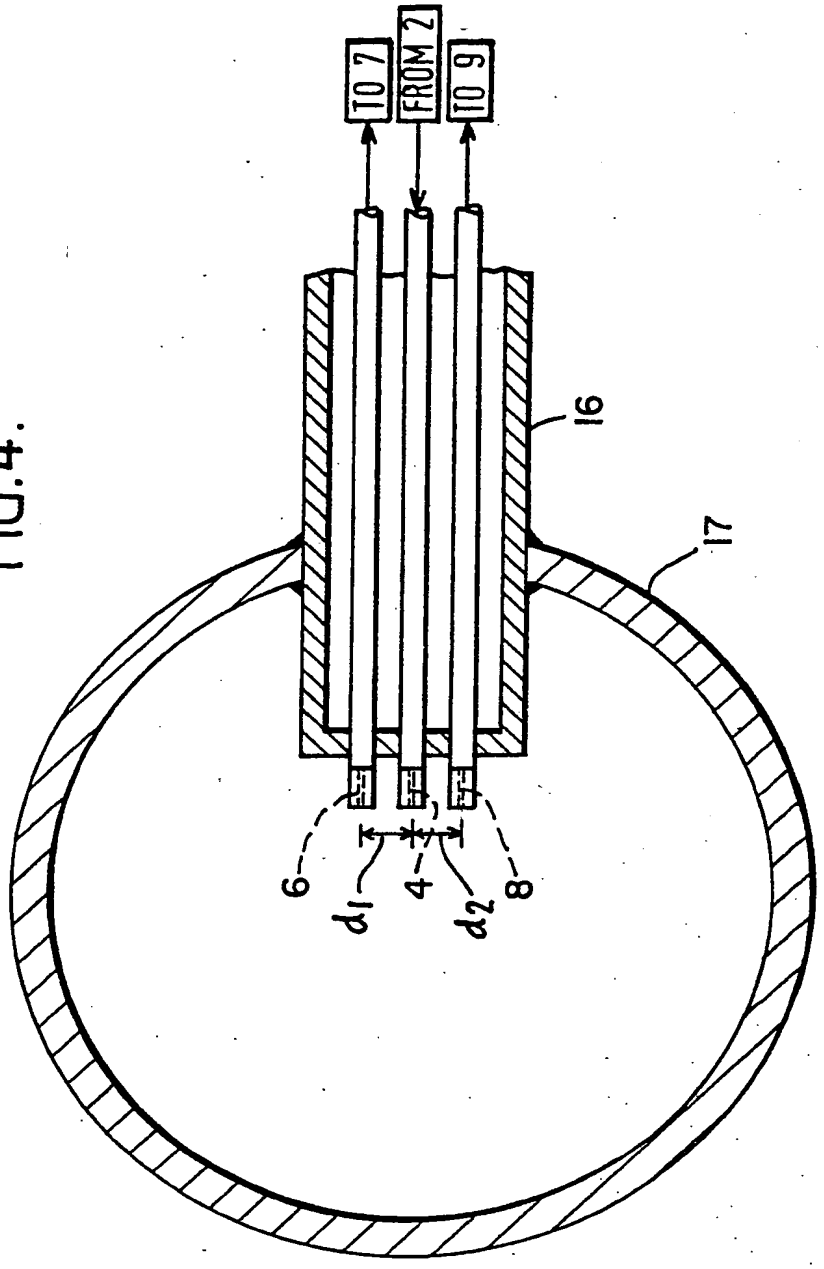


FIG.4.



INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 90/01529

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[5]: G 01 N 22/00

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[5]	G 01 N 22/00, G 01 N 22/04, G 01 N 33/28, G 01 F 1/74

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	US, A, 4423623 (W.H. HO et al.) 3 January 1984, see column 3, linges 19-65, lines 62-68; column 6 --	1,4,7,12,15
X	US, A, 3498112 (D.D. HOWARD) 3 March 1970, see column 3, lines 30-75; column 4, lines 1-41; figure 3 --	9,15
X	US, A, 4774680 (J. AGAR) 27 September 1988, see column 2, lines 52-65; column 3, column 5, lines 19-64 --	1
A	US, A, 4503383 (J. AGAR et al.) 5 March 1985, see column 3, lines 21-68 (cited in the application) --	1,8
A	US, A, 4764718 (D.E. REVUS et al.) 16 August 1988, see column 4, lines 21-68; column 5, lines 1-61 --	1
A	US, A, 4257708 (N. FUKUDA) 24 March 1981, see column 6, lines 53-68; column 7, lines 1-25 --	1

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
15th January 1991	31. 01. 91
International Searching Authority	**Signature of Authorized Officer**
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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, 11 with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	Patent Abstracts of Japan, vol. 2, no. 20, page 11346E77, 9 February 1978 & JP, A, 52139464 (TOKYO SHIBAURA DENKI) 21 November 1977 see abstract --	1
A	Review of Scientific Instruments, vol. 50, no. 10, October 1979 American Institute of Physics (US) N. Abuaf et al.: "Radio-frequency probe for bubble size and velocity measurements", pages 1260-1262, see paragraphs 1,2	1,7

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 9001529

SA 40696

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 25/01/91
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 4423623	03-01-84	CA-A- 1185658	16-04-85
US-A- 3498112	03-03-70	None	
US-A- 4774680	27-09-88	None	
US-A- 4503383	05-03-85	EP-A,B 0084405	27-07-83
		JP-A- 58129220	02-08-83
US-A- 4764718	16-08-88	None	
US-A- 4257708	24-03-81	JP-A,B,C54144043	09-11-79
		JP-A,B,C54144044	09-11-79
		JP-A- 54144045	09-11-79
		JP-A,B,C54144046	09-11-79
		AU-B- 523922	19-08-82
		AU-A- 4624079	01-11-79

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